

Course Title: Control Engineering
Date: 24/1/2017 (First term)Course Code: CCE3115
Allowed time: 3 HoursYear: 3rd Comp.
No. of Pages: (2)**Problem number (1) (17 Marks)**

The open loop T.F of a system is given as:

$$GH(S) = \frac{K}{S(S+6)(S+8)}$$

- (i) Sketch the root locus.
(ii) Determine the range of K for system stability.

Problem number (2) (18 Marks)

Consider the following open loop T.F:

$$GH(S) = \frac{10}{S(1+S)\left(1+\frac{S}{100}\right)}$$

- (i) Sketch the bode diagram for the system.
(ii) Determine the gain margin (GM), phase margin (PM), the phase crossover frequency (ω_{pc}), the gain crossover frequency (ω_{gc}).
(iii) State whether the system is stable or not.

Problem number (3) (20 Marks)

- a) Explain the common classification of controllers and to what type of controllers a phase lead and a phase lag compensators belong? (6 Marks)
b) Consider a system with the following open loop T.F: (14 Marks)

$$GH(S) = \frac{K(S+2)}{S(S+1)(S+3)}$$

Design a suitable compensator to meet the following specifications:

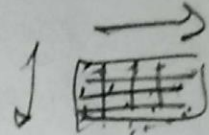
- The steady-state error to a unit ramp input must not exceed 1 %
- The damping ratio of the dominant closed-loop poles is $\zeta = 0.5$
- The magnitude of the real part for the desired poles = 2

Problem number (4) (20 Marks)

a) Explain the usage of a state-feedback controller and a full order observer. (4 Marks)

b) Consider the following transfer function of a system, (6 Marks)

$$\frac{Y(S)}{R(S)} = \frac{S^2 + 1}{(S + 2)(S - 2)(S + 3)}$$



(i) Obtain the corresponding state space model in controllable form and observable form.

(ii) Draw the state diagram for each form.

c) The state-space representation of a continuous system is given by: (10 Marks)

$$\dot{x}(t) = \begin{bmatrix} 1 & 0 \\ 0 & -0.5 \end{bmatrix} x(t) + \begin{bmatrix} 1 \\ -1 \end{bmatrix} u(t)$$

$y(t) = [2 \quad -1] x(t)$

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$$\begin{bmatrix} 1 & 1 \\ -1 & 0.5 \end{bmatrix}$$

$$\begin{bmatrix} 2 & -1 \\ 2 & 0.5 \end{bmatrix}$$

- Check the system controllability and observability.
- Find the system characteristic equation and check the system stability.
- Using pole-placement design, design a state-feedback controller to locate the closed loop poles at $S_{1,2} = -1 \pm j2$.
- Design a full order observer for the above system, the observer poles are desired to have damping ratio $\zeta = 1$ and settling time (t_s) equal to one-half the settling time value of the desired poles in part (iii).

$$t_{s2} = \frac{4}{1 \times 2} = 2$$

$$\frac{4}{1 \times 2} = 2$$

$$\omega_n = 2$$

$$\omega_n = 2$$

$$S_1, S_2 = -2$$

Good luck

$$S^2 + 4S^2 + 8$$

$$\begin{pmatrix} 9 & 0 \\ 0 & 2.25 \end{pmatrix}$$

$$\frac{16}{3}$$

$$17/8$$

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$$\begin{pmatrix} 3 \\ 1.5 \end{pmatrix}$$